

# **Comprehensive Numerical Modeling of the Adriatic Sea**

Principal Investigator - Benoit Cushman-Roisin  
Thayer School of Engineering  
Dartmouth College  
Hanover, NH 03755-8000

E-mail: benoit.cushman-roisin@dartmouth.edu  
Telephone: 603-646-3248  
Fax: 603-646-3856

Co-PI: Christopher E. Naimie  
Thayer School of Engineering  
Dartmouth College  
Hanover, NH 03755-8000

E-mail: christopher.e.naimie@dartmouth.edu  
Telephone: 603-646-2119  
Fax: 603-646-3856

## **Long-Term Goal(s)**

A better understanding of naturally occurring fluid turbulence via modeling studies on entrainment, mixing and convection in the coastal ocean. Development and use of models for the study of generic processes and for the investigation of specific oceanic regions. Transition of these models to ONR.

## **Scientific/Technical Objectives**

Development of a comprehensive, finite-element model of the Adriatic Sea, with initial focus on the seasonal circulations and later applications to mesoscale variability. Performance comparison of this model with other existing models applied to the Adriatic.

## **Approach**

The 3D finite-element model developed at Dartmouth (Lynch et al., 1996) was selected, and a high-resolution mesh was constructed for the Adriatic from the finest available topography and coastline data sets available. The model is then progressively developed and tested according to the following stages: (1) Precise tidal simulations to determine tidal residual currents, (2) simulation of the circulation on seasonal time scales, (3) study of events on scales of days and weeks, (4) performance comparison with other models, (5) focus on particular regions.

## **Task Completed or Technical Accomplishments**

Report Documentation Page				Form Approved OMB No. 0704-0188	
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.					
1. REPORT DATE <b>30 SEP 1997</b>		2. REPORT TYPE		3. DATES COVERED <b>00-00-1997 to 00-00-1997</b>	
4. TITLE AND SUBTITLE <b>Comprehensive Numerical Modeling of the Adriatic Sea</b>				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) <b>Dartmouth College,Thayer School of Engineering,Hanover,NH,03755</b>				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT <b>Approved for public release; distribution unlimited</b>					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT <b>Same as Report (SAR)</b>	18. NUMBER OF PAGES <b>3</b>	19a. NAME OF RESPONSIBLE PERSON
a REPORT <b>unclassified</b>	b ABSTRACT <b>unclassified</b>	c THIS PAGE <b>unclassified</b>			

To date, the tidal simulations have been completed. This, however, was a far more arduous task than anticipated. Indeed, a state of near resonance in the Adriatic amplifies the relatively weak tidal forcing from the Mediterranean, and tidal amplitudes and currents in the northern part of the sea are highly sensitive to turbulent dissipation.

Next, we acquired data sets: river discharges, surface fluxes and hydrography on climatological scales. Objective analysis was then performed to adapt these data to the finite-element mesh.

Finally, other data bases have been located for later studies of the variability at shorter than seasonal scales (winds, river discharges, and surface buoyancy fluxes during specific episodes of high variability).

## **Results**

Although tides are not a dominant signal even in the northern Adriatic where they are the strongest of the whole Mediterranean, tidal residual currents are nonetheless significant in areas of abrupt coastline and topographic variations, particularly along the fragmented Dalmatian coast (Croatia). A refined study of the tides was necessary to obtain reliable values for the residual currents, and this study revealed a high level of interdependency among the seven primary tidal components: each mode contributes to the level of turbulent dissipation affecting all others.

The analysis of the hydrographic data for each of the four seasons pointed to deficiencies in some of the sets (e.g., missing temperature and salinity signatures of coastal currents), and special care was necessary to interpolate/extrapolate these data on the high-resolution finite-element mesh. A search had to be conducted to determine the optimal values of alongshore and offshore correlation scales to be used in objective analysis. A search has also been undertaken to obtain regional data sets as supplements to the basin-wide sets.

## **Impact(s) for Science & Technology and/or Application**

Given the early state of this project, it is premature to claim any impact. However, fruitful collaborations have been established with several research teams in Italy, Slovenia, and Croatia and the ONR-supported Dartmouth initiative is already considered as a substantial contributing effort to the study of the Adriatic Sea.

## **Transitions Accomplished and Expected**

None to date.

## **Relationship(s) to Other Projects for ONR or Other Agencies**

Collaborations have been initiated in the USA with Prof. Pierre-Marie Poulain (Naval Postgraduate School) and Dr. Charles Horton (Naval Oceanographic Office), who are involved respectively in Adriatic drifter data and in Mediterranean-wide simulations.

Abroad, closest ties are with the modeling group in Bologna (Italy) under Dr. Nadia Pinardi (using the Princeton Ocean Model) and with groups of observationalists in Trieste (Italy), Piran (Slovenia) and Zagreb (Croatia). These teams are currently active in several national and European-Community projects.

## **References**

Lynch, D.R., J.T.C. Ip, C.E. Naimie, and F.E. Werner, 1996: Comprehensive coastal circulation model with application to the Gulf of Maine. *Cont. Shelf. Res.*, 16, 875-906.